Q: We are working on an electrical application and want to evaluate a process to resistance braze a joint with two overlapping sheets of C102 copper foil. The joint area is quite small, approximately 0.080 × 0.400 in. (2 × 10 mm), although the exact dimensions have yet to be determined. We are using a resistance welding unit and would like as short a heating time as possible — a few seconds preferably. We are using a BCuP-5 braze alloy without flux.

The issue we are having is that we are only getting a partial braze joint, where the electrodes impact the copper. If we increase the power, we get a weld at that location. Reducing the power and extending the time results in difficulty with getting any bond at all. The electrode is Cu-W and the contact area where it impacts the copper is about 0.070 in. (1.8 mm) in diameter. What do you suggest we do to enable a braze joint to be made of the entire overlap area?

A: You are fighting a couple of things in attempting to achieve your goals. Both of them relate to the properties of copper. While we normally think of copper as one of the most straightforward things to join, there is usually a devil in the details. In the case of resistance brazing of copper, a few of them can pop up.

We commonly think of resistance welding or brazing in terms of making the joint an integral part of an electrical circuit. The current flows from an electrode and through the material being heated and, possibly, a preplaced piece of brazing filler metal. The resistance of the material to the applied current causes the part to heat, melt the filler metal, and create a braze joint. If there is no filler metal and the current and electrode pressure are high enough, you will create a weld.

The issues you must deal with here relate to the electrical and thermal conductivity of copper. You are using a highly conductive electrode of copper and tungsten. When these electrodes impinge on the surface of the copper, sandwiching the joint between them (see Fig. 1), a current passes through the layers of the joint. Because the joint consists of copper and a copper/silver filler metal (with some phosphorus), the joint electrical conductivity will be quite high. This high conductivity is why you use it in electrical applications, but it works against you in this instance. It takes more power and time for the heat to develop in the joint. Your goal of doing this quickly is difficult to achieve.

This is where the high thermal conductivity of copper comes in. What seems to be going on is that as you heat the joint area between the electrodes, the copper is pulling heat away from the joint. You increase the power to get enough heat in the joint and eventually you get a weld. This is probably okay metallurgically, but it will be localized and limited to the area between the electrodes. You will not get capillary flow to fill the joint.

The thermal conductivity of copper is shown below. I have included the thermal conductivity of SAE 1020 steel as a comparison. I have not included the figures for electrical resistivity of these materials, but they are of the same magnitude of difference.

<table>
<thead>
<tr>
<th>Material</th>
<th>Thermal Conductivity [W/m°C]</th>
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<tbody>
<tr>
<td>OFHC C102 Copper</td>
<td>2712 (BTU/(in.)/(hr)/(°F)) or 391 W/m°C(K)</td>
</tr>
<tr>
<td>SAE 1020 Steel</td>
<td>357 (BTU/(in.)/(hr)/(°F)) or 51 W/m°C(K)</td>
</tr>
</tbody>
</table>

*Data taken from the AWS Brazing Handbook

With the electrodes and base metals you are using, you will have difficulty generating heat in the joint to get the degree of braze joint you desire due to the high electrical conductivity of the copper. In addition, the heat you generate will be hard to keep in the joint due to the high thermal conductivity pulling it away, making capillary flow to fill the desired joint size nearly impossible.

An alternate approach is to use electrodes where the heat is generated in the electrode rather than the braze joint. There is a rule of thumb that when resistance brazing of materials with high electrical conductivity, you use electrodes with low electrical conductivity. You obtain heat for brazing from the electrodes rather than relying on the resistance of the braze joint. The opposite approach holds when the materials you are joining have low electrical conductivity.

One of the most common high resistance materials used for achieving this is graphite. In your application, you are attempting to achieve a braze joint over a broad area, 0.080 × 0.400 in. (2 × 10 mm). In this example, it would be recommended that the graphite electrodes be machined to this size so they directly heat the entire area to be...
BRAZING Q&A
— continued from page 21

joined. An example of this type of brazed joint can be seen in Fig. 2. The braze filler metal is sandwiched between two pieces of copper and the graphite electrodes are placed on the outside, plus pressure is applied. The heat is generated in the graphite and transferred to the parts. There are certainly other electrode materials with high resistivity that can be used. Graphite is often chosen due to its low cost.

You mention that the copper is in foil form, which implies it is quite thin. It should heat quickly and, as you would be heating the entire joint area, there would not be a loss of heat. These types of braze processes can be automated so a cycle time of a few seconds could most likely be achievable.

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This column is written sequentially by TIM P. HIRTHE, ALEXANDER E. SHAPIRO, and DAN KAY. Hirthe and Shapiro are members of and Kay is an advisor to the C3 Committee on Brazing and Soldering. All three have contributed to the 5th edition of the AWS Brazing Handbook.
Readers are requested to email their questions for use in this column to the authors, cwbhi@aws.org, or send to their attention at Welding Journal, 6669 NW 36 St. #130, Miami, FL 33166.

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— continued from page 50

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